



# Using Topographic Engineering to Achieve Dominance in Urban and Complex Terrain

By Mr. Ken Bergman

Maneuver warfare concepts have been developed and used very effectively over the past three decades to achieve unprecedented levels of success in Operation Desert Storm in 1991 and Operation Iraqi Freedom in 2003. Much of the combat in these conflicts entailed operations in open and rolling terrain. The reason we dominate maneuver in such terrain is largely due to the fact that we dominate the information in that environment, and we are able to deploy weapons systems and maneuver platforms that overcome threat forces before they can interdict our forces.

In contrast, urban and complex terrain presents a more challenging operating environment in that threat forces can get closer to our soldiers before we can bring superior combat power to bear. Unless we are properly prepared, threat forces can make devastating attacks on our units in this type of terrain. The threat can employ explosive devices and snipers to hit allied targets of opportunity and can also employ suicide bombers in vehicles.

Information dominance and dominant maneuver are harder to achieve in urban and complex terrain, but there are measures we can take to give our soldiers important advantages. Engineer solutions include physical measures to interdict threat forces, such as countermeasures and emplacement of barriers, as well as command and control (C2) measures that can enhance our information dominance. This article focuses on how the topographic engineering component of information dominance helps achieve dominant maneuver in urban and complex terrain.

C2 capabilities are closely associated with any information dominance solutions. The “observe, orient, decide, act (OODA) loop” is a simple model for understanding C2.<sup>1</sup> The OODA loop is used unconsciously by competing opponents. The Army military decision-making process is a very detailed version of the OODA loop. At a very basic level, the OODA loop can be compared to a boxing match: A combination of speed and a variety of different punch combinations (as well as defensive parries)—delivered at a high tempo—can rapidly overcome an opponent. Extrapolate the OODA loop to a brigade

or higher echelon, and the level of complexity of divergent decision trees grows exponentially. Geospatial information and services (GI&S) provide the foundational basis for C2 decisions in all phases of the OODA loop, helping soldiers understand the lay of the land and act on that understanding, in both open and rolling terrain and urban and complex terrain.

## Solutions Available Now

Combat field commanders are very focused on rapid solutions to meet their C2 needs. There are several topographic engineering tools available today that can help soldiers achieve a better understanding of the terrain and make better decisions. Each of these capabilities can be employed to help warfighters achieve assured mobility in urban and complex terrain with an accelerated and more effective OODA loop.

**Urban Tactical Planner™ (UTP).** UTP is a planning tool intended to support military operations in urban terrain (MOUT). It is a very capable, user-friendly tool for terrain understanding, but many people are still unfamiliar with this product. UTP provides an overview of the urban terrain in the form of maps, imagery, elevation data, perspective views, handheld photography, video clips, scanned building plans, tables, and text. It provides three-dimensional (3-D) visualization of key aspects of the urban environment—including buildings, roads, railroads, streams, forests, marshes, water bodies, and vertical obstructions (see Figure 1). UTP is intended for rapid dissemination on a compact disk (CD) and Intelink-S. The product can be built on short timelines to meet contingency planning requirements as they arise.

TerraExplorer® is a software package used to run UTP. The TerraExplorer viewer file runs on any laptop or personal computer, with no license fees; it can therefore be copied as often as needed and disseminated to as many users as required. Dissemination in the field is limited only by security procedures. UTP allows soldiers to view the terrain numerous times before deploying to an area. The US Army Corps of Engineers® Engineer Research and Development Center

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(ERDC) Topographic Engineering Center (TEC) builds and disseminates UTP over many key urban areas.

TEC builds a separate custom product (regional fly-throughs) that uses the same TerraExplorer software found in UTP. This stand-alone product uses elevation data, imagery, feature data, and annotated points of interest to provide users with terrain understanding over a large area (hundreds of miles). Regional fly-throughs can consist of a single country or an entire region. Like UTP, the regional fly-through is easy to use and runs on any laptop or personal computer. It can be disseminated using a digital video disk (DVD) or a FireWire (external hard drive), depending on file size. It can be copied for as many users as needed, without cost, subject to security procedures.

**Improvised Explosive Device (IED) Detection – Buckeye.** Finding IEDs in urban and complex terrain is a challenging task, and geospatial technology is part of the solution. Many initiatives are in the planning phase or are going through research, development, and engineering processes. The Buckeye program has shown significant success in theater. Details regarding the program are available from TEC.

**Handheld Geographic Information System (GIS) Personal Digital Assistant (PDA).** GI&S tools have advanced to the point where they can now be deployed on Global Positioning System (GPS)-enabled PDAs. Cutting-edge PDAs in the field today enable users to digitize important features (such as road and bridge information, minefields, and obstacles). These PDAs are an early example of the soldier as a primary source of digital terrain data. It has been said that every soldier is a sensor. Handheld PDAs with embedded geospatial software enable the Army to implement this tenet in digital form.

**Terrain Team Support.** Terrain teams are the critical links between GI&S technologies and ground warfighters. The Army has fielded terrain teams with world-class GIS capabilities down to the brigade level. Army terrain teams are able to build rapid-response products that lead to terrain understanding, which is a key component of information dominance. The Digital Topographic Support System (DTSS) is the C2 system used by Army terrain teams. The DTSS is supported by the Combat Terrain Information Systems (CTIS) project office. Terrain teams produce customized terrain analysis products, 3-D fly-throughs, perspective views, masked area plots, line-of-sight analyses, and hard-copy printouts of custom geospatial products. Terrain teams in theater have been developing new methods to address the complex nature of urban terrain with cutting-edge analysis tools. Additional capabilities are provided using reachback to terrain teams at higher echelons (division and corps), theater-level Army assets (Theater Geospatial Database), TEC, and the National Geospatial-Intelligence Agency (NGA). Each level provides support to terrain teams at the “pointy end of the spear.” TerraExplorer software was recently delivered to the terrain teams, so they are now able to edit existing UTP products and regional fly-throughs and to build their own fly-throughs in theater from source data.

It is essential that we continue to sustain these teams with current, updated hardware and software and—more importantly—with trained, motivated soldiers who can make innovative products in the field to support the warfighter. It is also essential that these teams remain tightly linked to reachback assets to ensure that they have the very best possible products available for the maneuver element.



**Figure 1. Urban Tactical Planner**

## Solutions Available in the Future

**N**ew technology solutions will give soldiers increased information dominance in the future. Some of these capabilities are available today in the commercial world and need to be packaged for use in the field. Other capabilities are still in the initial stages of development:

**Light Detection and Ranging (lidar) Systems.** Lidar uses an active energy source (laser) to find the range to a distant object. This is similar to radar, which uses radio waves to detect distant objects. Using the laser time of flight and precise location of an airborne or vehicle-mounted lidar sensor, this system can be deployed to collect extremely accurate elevation data (1-meter post spacing or better). This is a mature technology that is used throughout the developed world to achieve detailed terrain understanding and analysis. For example, cellular telephone companies can use lidar elevation data to find the optimal locations for towers to maximize communications coverage for their customers. In the tactical world, this data set can be used to build a number of useful products, to include detailed 3-D fly-throughs and line-of sight analyses; identify ambush sites, dead space, and avenues of approach; and generate detailed feature data (see Figure 2).

Important engineering tasks can be accomplished using lidar, to include repair of buildings and precise estimates of

volume and mass in a small hill of gravel or other material. For example, ground-based lidar was used to measure the size of granite slabs used to repair the Pentagon after 9/11, and airborne lidar was used to estimate the amount of material to be removed from the Twin Towers site in New York City. Applications for lidar in the tactical environment are readily apparent.

**Urban Terrain Information Constructs (UTICs) - Battlespace Terrain Reasoning and Awareness (BTRA).** This program is developing automated terrain reasoning tools for use on digital C2 systems. BTRA uses feature data with embedded attribution ("right-click") data and elevation data to provide live course of action (COA) analyses. The BTRA program has produced some useful cross-country tools for warfighters for real-world applications. Emerging BTRA developments are providing advanced, dynamic terrain reasoning tools to aid in the preparation, management, and assimilation of observation, cover and concealment, obstacles, key terrain, and avenues of approach (OCOKA), as it relates to intelligence preparation of the battlespace. The intent is to use both coarse and fine terrain data sets to build tools that will help achieve assured mobility.

UTICs is an initiative to build BTRA-like tools for terrain reasoning in the urban battlespace. UTICs will gain major

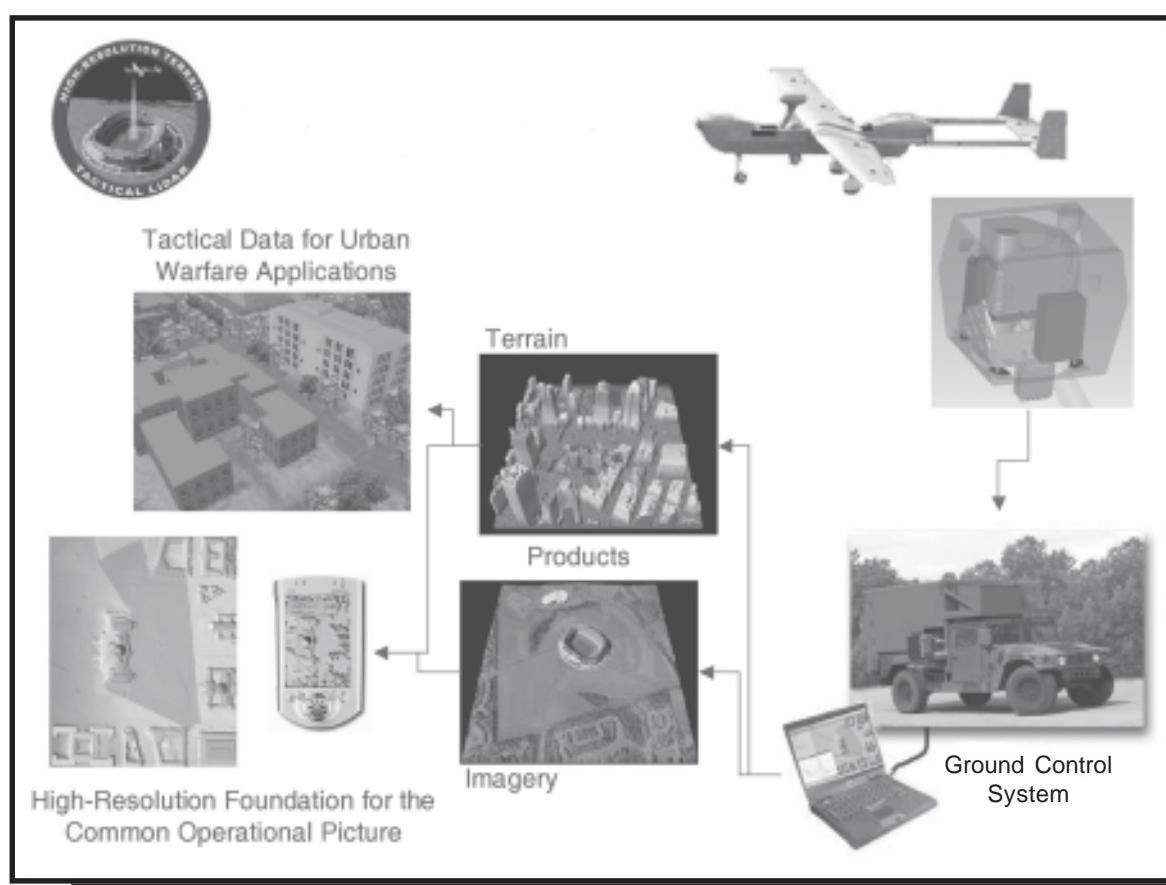


Figure 2. Tactical Lidar

computational efficiencies for dynamic situational understanding of the effects of urban environment by reasoning against critical geospatial aspects of urban terrain. By representing the urban and complex terrain as network- and object-based abstractions, soldiers will be able to rapidly make tactical decisions in a changing tactical environment, thereby increasing their pace of C2 decision making (achieving a faster OODA loop). Immense efficiencies can be gained in both the computation time required to perform COA analyses and the bandwidth requirements for transmitting/sharing decision support data. These geospatial capabilities will also provide a framework to support management of cultural and civil information that will be needed to support COA analyses demanded by the command requirements of the “3-block war.”

UTICs endeavor to explore both the establishment and use of an abstract representation of urban environments, and the means to disseminate dynamic information to platforms on the move.

**3-D Solid Terrain Models.** TEC is building solid terrain models of several cities, with imagery embedded in the models, for numerous customers. Individual 3-D buildings are “stood up,” and avenues of approach can be examined from various angles. These hard-surface models are produced using computerized elevation data linked to a machine that deposits layers of plaster that represent buildings. Colored plaster is deposited to represent imagery overlaid on the buildings. The plaster model is then hardened so it can withstand normal handling by users. These tools are different from digital 3-D fly-throughs, since users can handle the model, view the terrain from different angles, and brainstorm contingencies in a group setting. Many users employ this tool—in addition to computer-based visualization—to achieve better terrain understanding.

**Joint Geospatial Enterprise Service (JGES) – Army Prototype Program (APP).** JGES is an initiative that brings joint GI&S assets together in an enterprise (distributed) environment to maximize the availability of terrain data and products. One of the central aspects of JGES is the intent to capture, archive, and reuse terrain data, from national sources to the individual soldier. The JGES Initial Capabilities Document (ICD) has been approved by the Army Requirements Oversight Council (AROC). The JGES-APP is an initial effort to leverage and integrate distributed geospatial capabilities to support the warfighter. The JGES-APP architecture includes a central hub at TEC with connectivity to field sites (such as the Terrain Visualization Center at Fort Leonard Wood, Missouri) and overwatch support for deployed units in theater. Specific goals in the JGES-APP include understanding how to provide reachback support to field units; conflation (merging) of disparate terrain databases; dissemination of new products using limited bandwidth; and archiving and reuse of terrain data generated in the field. The JGES-APP is an early instance of enterprise GI&S support to the field.

## Conclusion

**W**hile our forces have achieved phenomenal success in dominating open and rolling terrain, today’s soldiers face significant challenges in urban and complex terrain. Information dominance can help overcome these challenges. GI&S capabilities provide a foundational aspect for our forces to achieve a more rapid and effective C2 decision cycle (OODA loop). Several tools are available for use today, while others are emerging from technology development programs. It is imperative that we understand and employ appropriate geospatial assets to achieve assured mobility in urban and complex terrain.



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### Endnote

<sup>1</sup> The OODA loop is an information strategy concept for information warfare that was developed by Air Force Colonel John R. Boyd (1927-1997). He was instrumental in explaining and disseminating the concept of “cycle time” and “getting inside the adversary’s decision cycle.”



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